4. Collared coil.

4.1 Preload adjustment.

Room temperature preload for HGQ-05 in the inner ~65 MPa and outer layer ~ 70 MPa corresponds to a coil azimuthal size of +225 μm for inner and +150 μm for outer coils measured at 83 MPa. The inner coil size was approximately +215 μm [+0.0085 in], so they had not to be shimmed. The outer coil sizes were +305, +320 μm [+0.012, +0.013 in], so they needed to be shimmed down ward by –170, -155 μm [-0.007, -0.006 in]. One layer of the ground insulation (125 μm, 0.005 in) was removed from mid-plane and from pole regions for the outer coil. Than, one layer 75 μm (0.003 in) Kapton was added to the bearing strip. In additional to the body, the end region shim had been calculated according to end measurements taken every one-inch started from saddle ends.

4.2 Shim plan.

All coils had been shimmed downward at the parting plane and at the pole, uniformly across the coil from end-of-saddle to end-of-saddle. The shim plan is shown on figure 4.1.

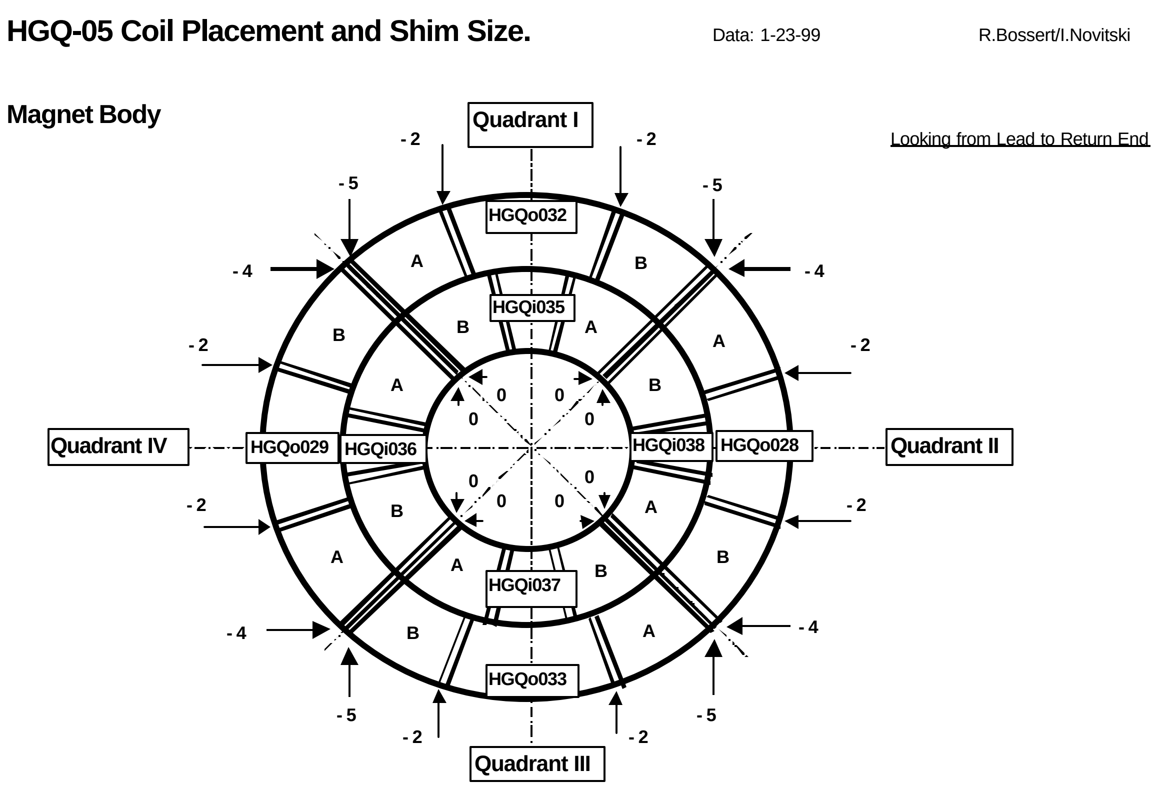

Figure 4.1. Magnet body cross-section.

4.3 Quench protection strip heaters.

Quench protection strip heaters were placed in between the inner and the outer layer and also added to the space between the outer layer and the collars (Fig.4.2). The strip heater assembly is 75 µm (0.003 in) thick for inner and 114 µm (0.0045 in) for outer layers. Inner heater consists of a 25 µm (0.001 in) stainless steel strip covered on each side by a 25 µm (0.001 in) Kapton "cover sheets". Outer layer (copper coated) Mac's heater is double element strip heater. This heater has twice bidder an effective surface and covered completely on quadrant of the coil assembly. To minimize the preload differences due to the strip outer heater, one of the Kapton cover sheets (the one facing the collars) was removed on the body. Finally, we have ~175 µm (0.009 in) Kapton insulation between each strip heaters and the coils body.

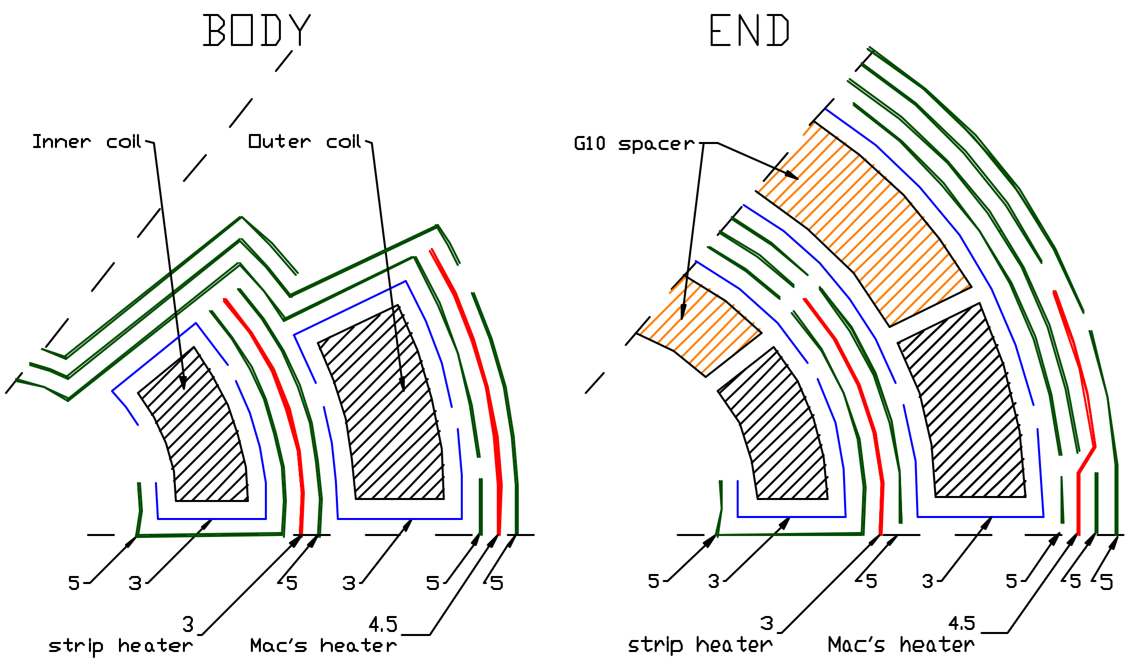

Figure 4.2. Strip heater location and ground wrap system.

At least 125 µm Kapton insulation covered heaters at transition and end areas. The ground wrap was modified specially at Lead and Return Ends to ensure there was no heater-to-collar ground short potential and to obtain end can deflections.

4.4 Strain gauges.

Coil size in the different quadrants along the magnet, which was calculated according to the coil size data, shimming data and coil location in the magnet is shown in Fig. 4.3.

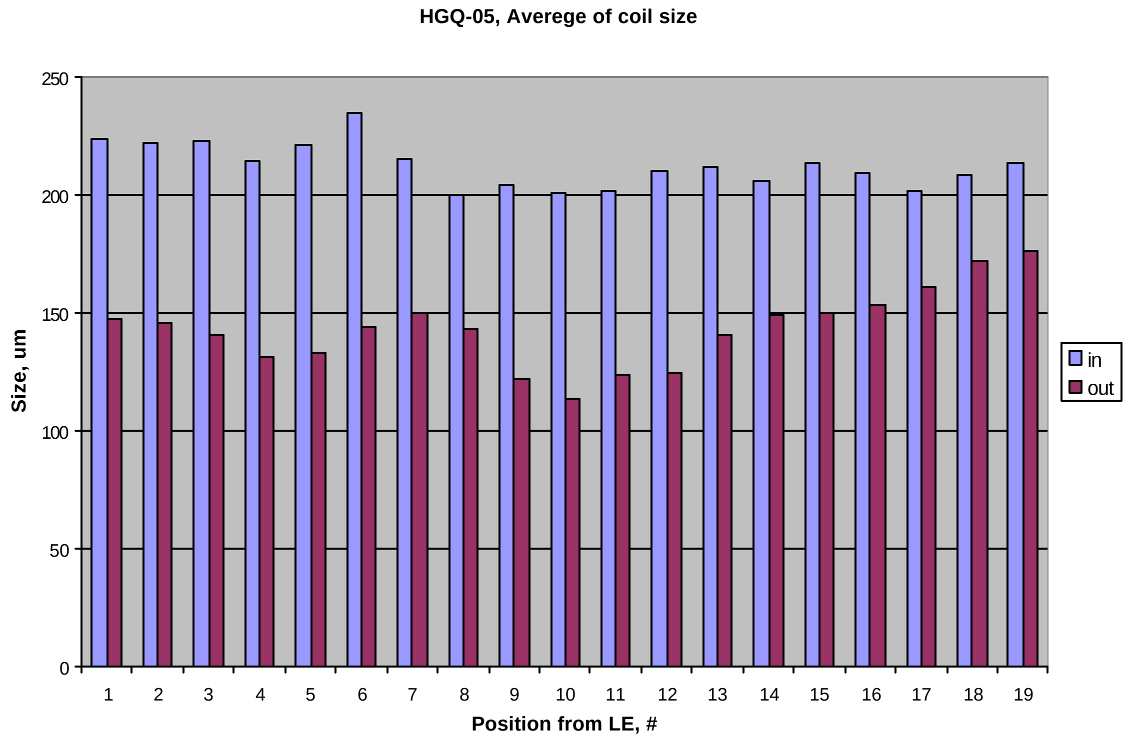

Figure 4.3. Inner and outer coil size by quadrant along the magnet (with respect to nominal).

Longitudinal positions #10 and #18 in the magnet body were chosen for strain gauge installation. Each strain gauge position is instrumented with two beam gauges, four temperature-compensating gauges, and with four capacitance gauges. Gauge locations are shown on Fig.4.4,4.5.

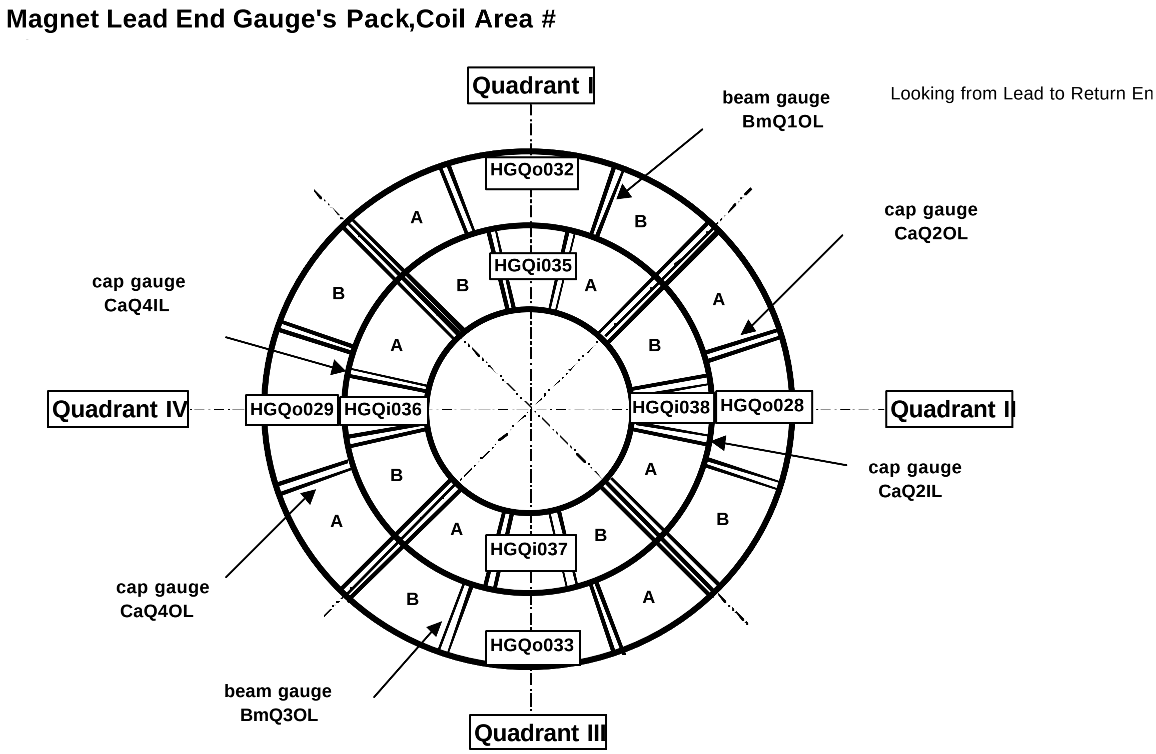

Figure 4.4. Magnet longitudinal position #10.

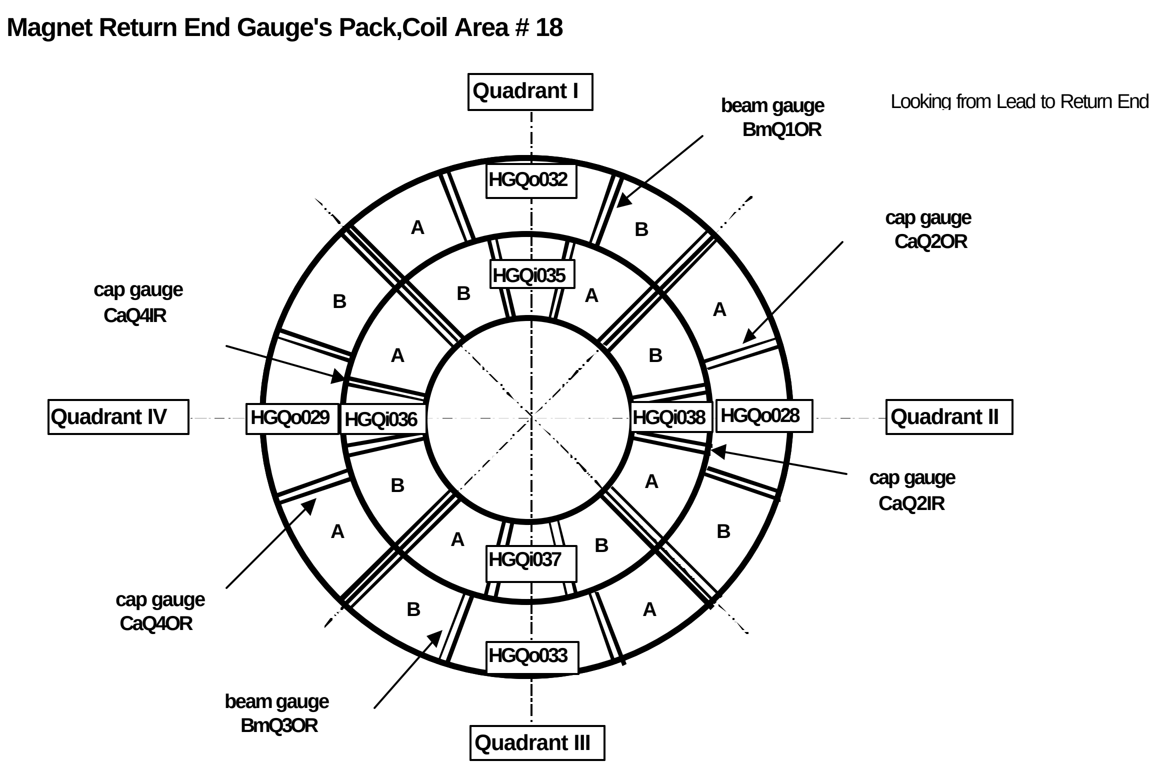

Figure 4.5. Magnet longitudinal position #18.

4.5 Keying.

Special collar pack was used to increase axial rigidity of the coil's body. The collar pack shown on Figure 4.6.

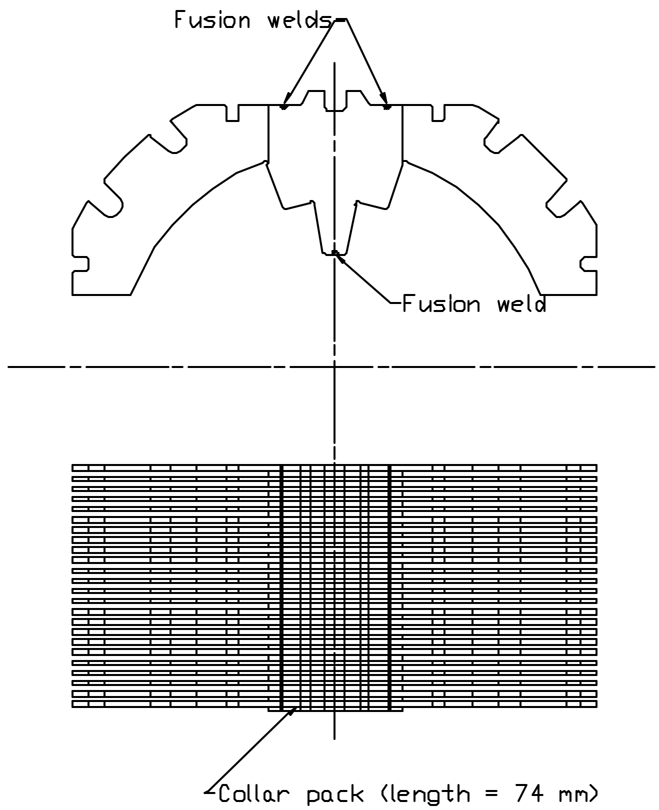

Figure 4.6. Collar pack.

Several different lengths of collar pack had been used, 74 mm (48 pieces), 75.5 mm (49 pieces), 72.5 mm (47 pieces), 48 mm (32 pieces) and 46.5 mm (31 pieces). Small bearing strips approximately same length as packs were placed on the packs. They were attached to the poles at the pack ends using 25 (0.001 in) tick adhesive Kapton tape. First and last packs were insulated at the ends to avoid coil-to-ground shorts, because no key extensions used in the magnet.
The magnet is packed started from Return End using the vertical keying press.
The collared assembly is "massaged" at 1500 and 3000 pump psi of the main pressure (MP), partially keyed by hand at MP=4500 pump psi. Final keying was done at MP=6500 pump psi using 3000 pump psi of the key pressure (KP). Short 3 in keys was used for keying. No shorts to ground during keying had been discovered.
Figure 4.7 shows pack's location along the body and keying procedure in details.

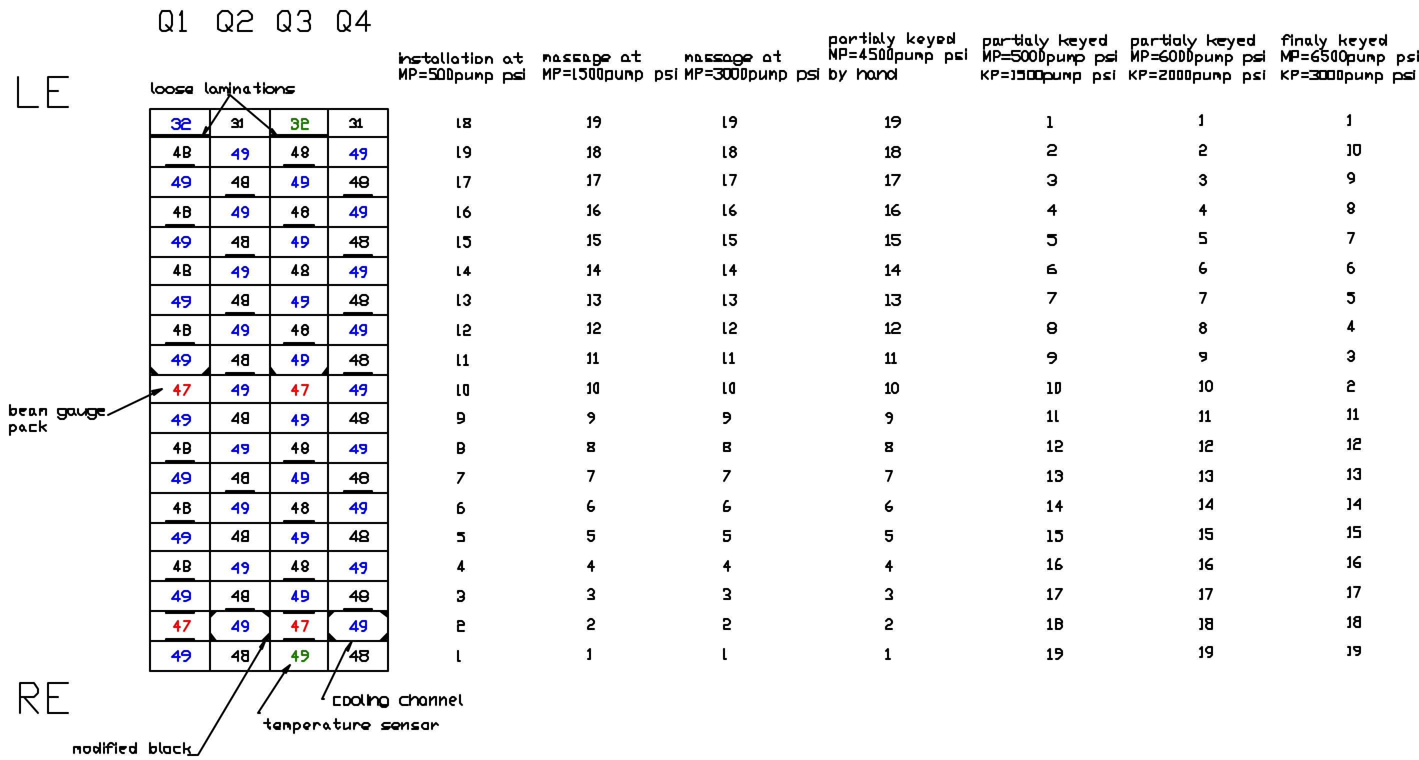

Figure 4.7. Map of packs and keying procedure.

4.6 Final pressures.

The final pressures after magnet keying are shown in Tab. 4.8. The strain gauges nearer the lead end are designated “lead end” and the strain gauges nearer the return end are designated “ return end”, even though the gauges are within the body, and not actually at the lead or return end.

Table 4.8 Final pressures.

Gauge ID	Type	Coil	Function	Quadrant	End	VMTF Name	IB#3 Data	
							Pressure	
							psi	MPa
LHCO025	Beam	O	Active	1	R	BmQ1OR	9233	64
LHCO026	Beam	O	Active	3	R	BmQ3OR	7736	54
LHCO027	Beam	O	Active	3	L	BmQ3OL	5014	35
LHCO028	Beam	O	Active	1	L	BmQ1OL	6766	47
HQCG58	Capacitance	I	Active	4	L	CaQ4IL	13434	94
HQCG59	Capacitance	I	Active	2	L	CaQ2IL	14198	99
HQCG61	Capacitance	O	Active	2	L	CaQ2OL	BAD	
HQCG66	Capacitance	O	Active	4	L	CaQ4OL	11096	77
HQCG62	Capacitance	I	Active	2	R	CaQ2IR	15567	109
HQCG65	Capacitance	O	Active	4	R	CaQ4OR	12004	84
HQCG67	Capacitance	O	Active	2	R	CaQ2OR	BAD	
HQCG68	Capacitance	I	Active	4	R	CaQ4IR	BAD	

4.7 Mechanical measurements.

The OD measurement data for collared coil block after RE can on show on Fig. 4.10, 4.11.

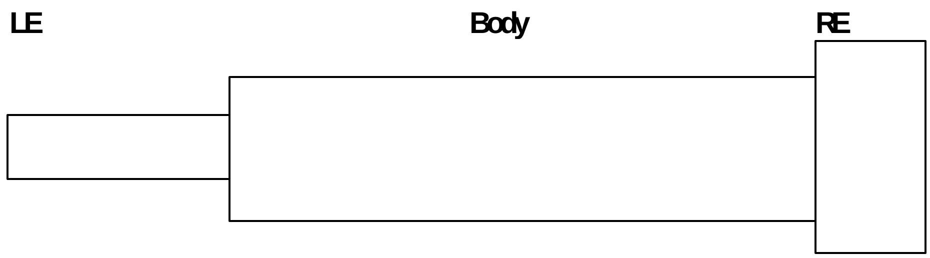

Figure 4.9. Collared coils with RE can on.

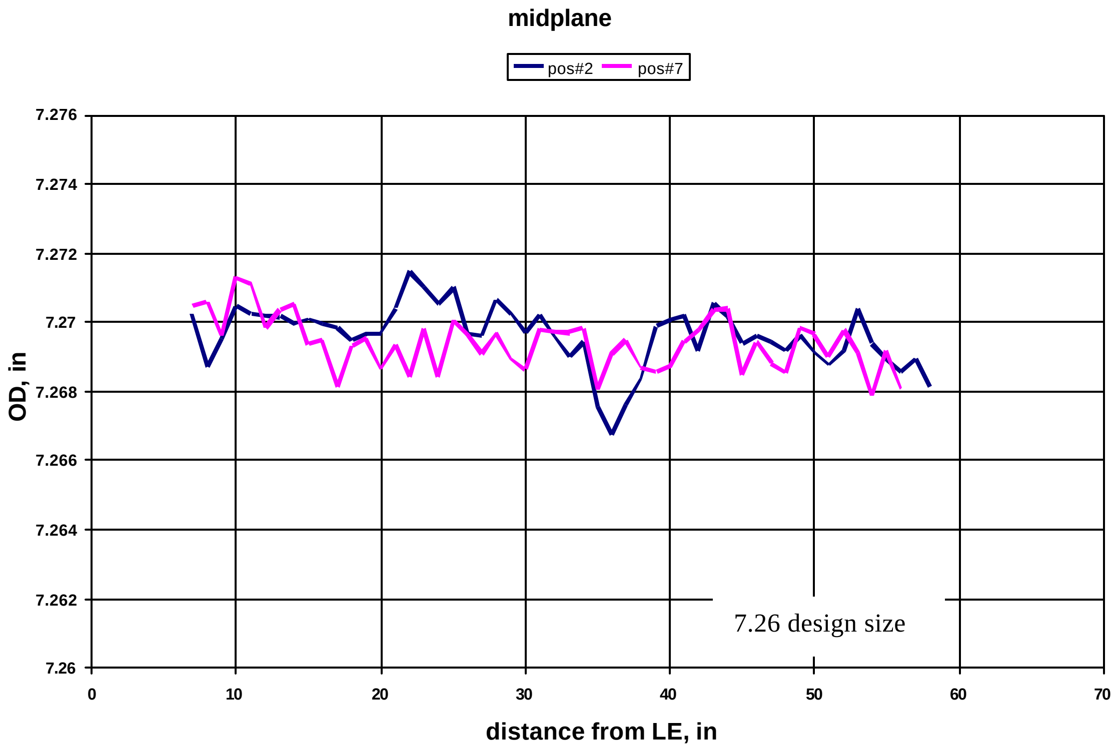

Figure 4.10. Collared coil deflections at midplane region.

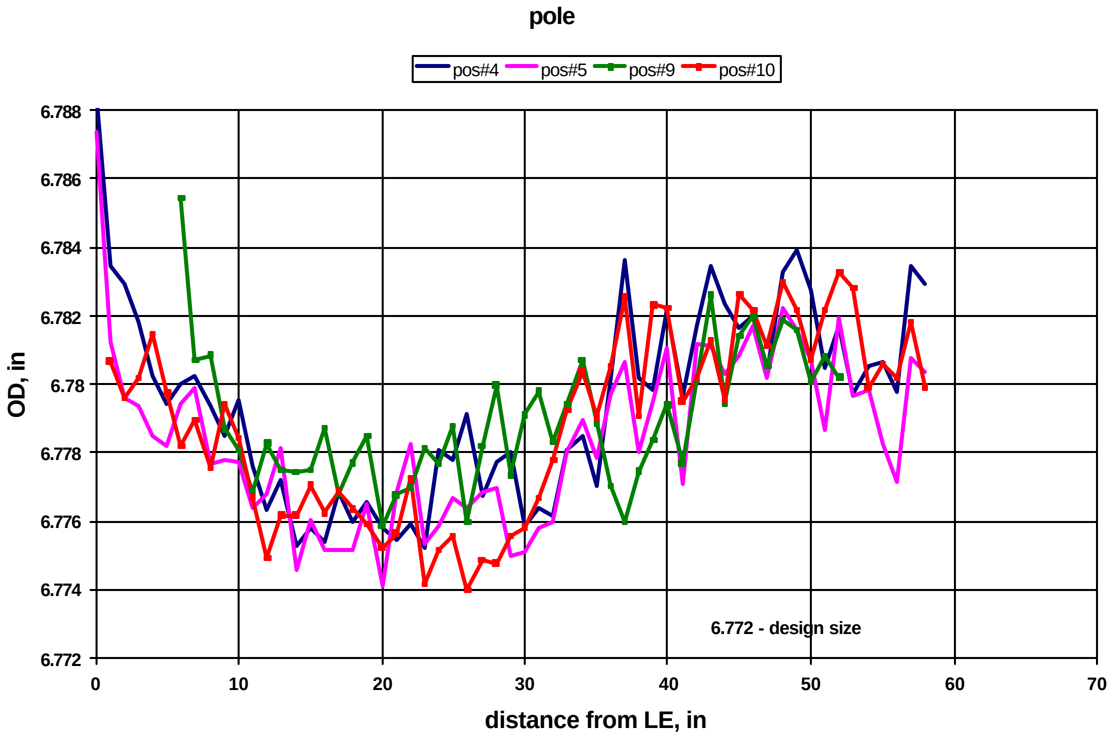

Figure 4.11. Collared coil deflections at pole region.

4.8 Splice.

The pole turn of each inner/outer coil pair needs to be spliced together. The internal splice configuration is used for HGQ-05. Splices are 114 mm long, which is approximately equal to the cable transposition pitch. Areas to be spliced are preformed, or filled with solder before the coil is wound. The tinned sections are then spliced after the magnet straight section is collared, keyed and the Return end can was installed. The maximum temperature for the turn next to the heater during the splicing processes was about 140 F. A cooling fixture was attached at the coil side so that the coil is not heated up. No cooling channels were made in the splice insulation.

4.9 End can.

Fuji film tests were performed before End can final installation.
The results of the Fuji film readings showed that there is a uniform radial pressure distribution from the transition region to the middle of the large current block and gradual, uniform decrease of pressure to the end-saddle.
The thickness of radial ground insulation surrounding the outer coil was increased by 130 μm [0.005 in] from the original design.
The End Cans were installed on the lead and return ends of the coil assembly using a longitudinal force of 66660 and 45000 lbs (at 9750 and 6500-pump psi). The radial deflection of aluminum ring according pi-tape measurements is ~ 140 μm [0.0055 in].

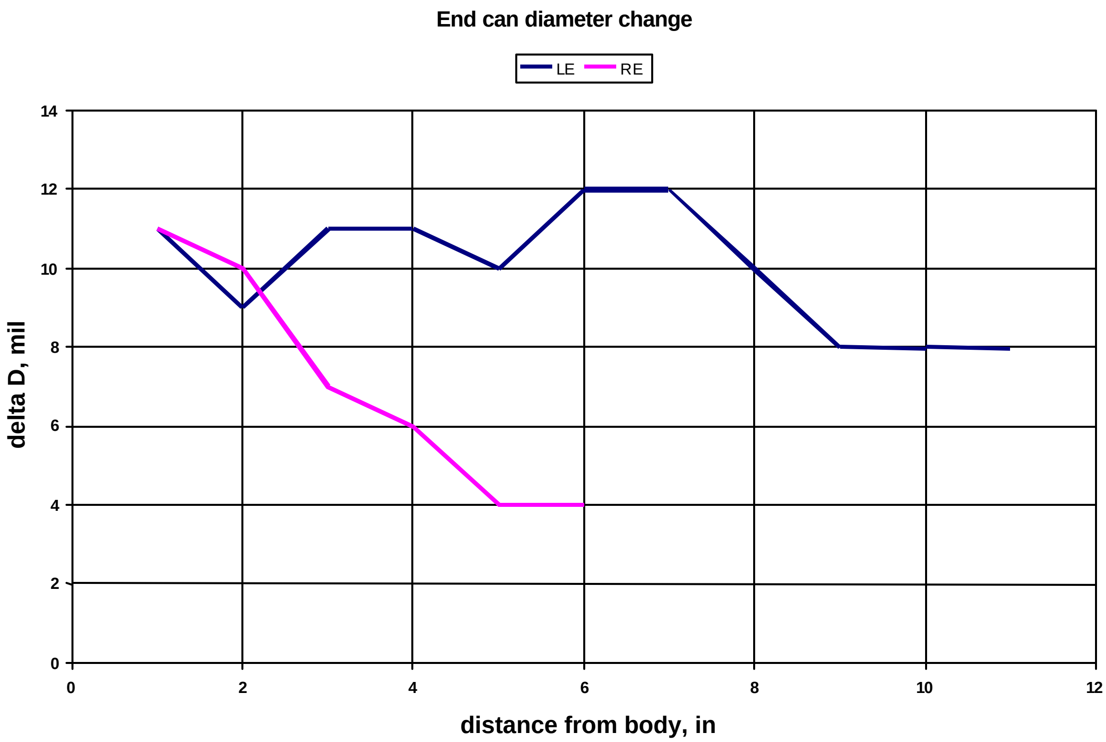

Figure 4.12. End can region.